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Enhancement of Voltage Profile by Using the L-Index Method to Place FACTS Optimally

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Abstract*: This paper examines an IEEE standard test system and uses MATLAB to test it using the Newton-Raphson method. Each bus's voltage magnitudes are analyzed, and FACTS like SVC and TCSC are added to the appropriate weak bus. The L-Index approach can be used to determine the best location for FACTS. When the L-index value approaches unity, it indicates that instability has been reached. The stability of the system is enhanced under fault and steady state situations from this instability point. By altering the Load Reactive Power at a certain bus, the system becomes disturbed.*

Keywords*: Steady State Condition, SVC, TCSC, MATLAB, Fault condition*

I. Introduction

The worldwide electricity supply industry experiences meaningful transitions because electric power requirements increase. The electricity transmission system functions at a high level of complexity due to its current design. The power system needs additional power transmission capabilities because the electricity demand keeps rising therefore new transmission lines or new devices for existing lines need to be deployed. Transmitting new power lines to a power system creates multiple technical problems involving expense and project duration together with economic considerations and environmental elements. The flexible alternating current transmission system (FACTS) enabled novel power control techniques that improved transmission line utility. The FACTS system depends on static equipment for transmitting electrical energy as AC [9]. The power system network achieves two goals through this method: it obtains greater power transfer abilities and establishes better control features. The definition of FACTS as a concept began with N.G. Hingorani in 1988. Electricity regulation through high-power semiconductors represents its main application for controlling active and reactive power alongside voltage levels and both impedance and phase angle together with current flow parameters. MATLAB code provides static modelling analysis of Static Var Compensator (SVC) and Thyristor Controlled Series Compensator (TCSC devices while explaining their voltage profile enhancement capabilities.

Using L-Index power systems can forecast their operational scenario with precision to avoid voltage collapse. The researchers from Kessel et al derived a voltage stability index through the solution of power flow equations. The system stability limit distance to its present state can be quantitatively measured through the L-index. The complete power system stability situation is defined through the L-index. At any particular operating condition of the system the estimator provides output that leads to a load flow result. The designed load flow algorithm combines generator control characteristics with the functional characteristics of load.

II. Static VAR Compensator

A unit that consists of static generator elements or absorbers with shunt connection functions as an SVC when operating through variable output to manage specific electrical power system parameters (mainly bus voltage). The primary use of SVCs exists in power systems because they provide stability improvements while controlling voltage levels. The new generation of SVC models relies on variable shunt susceptance principles otherwise known

as a distinct method from standard generator type descriptions. Newton–Raphson presents unified iterative solutions by integrating SVC state variables with network nodal voltage magnitudes and angles using one shared reference system. An SVC operates as an adjustable reactance whose operation remains limited by its firing-angle and reactance characteristics. Obtaining non-linear power equations and linearized equations for Newton's technique comes from the use of an analogous circuit [9].

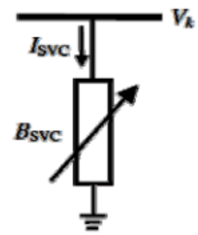

Fig 1: Variable shunt susceptance model

The TCSC functions as a capacitive reactance compensator which changes its series capacitive reactance value through switching series capacitors with a thyristor-controlled reactor. The basic design of TCSC modules in Figure 2 shows the connection of LS thyristor-controlled reactor paralleled with C series capacitor. The power flow model of this section implements a variable series reactance to automatically control branch power flow at specific levels according to predetermined values. The chosen approach through Newton's method allows for determining the amount of reactance. XTCSC represents the variable reactance value which belongs to each module within the TCSC series connection.

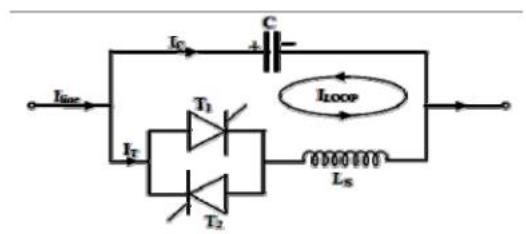

Fig 2: Thyristor-controlled series compensator

III. Results and Discussion

A custom-built MATLAB code generated observations by implementing the Newton Raphson method under two conditions for a FACTS validation on the IEEE 5-Bus test system [7-9].

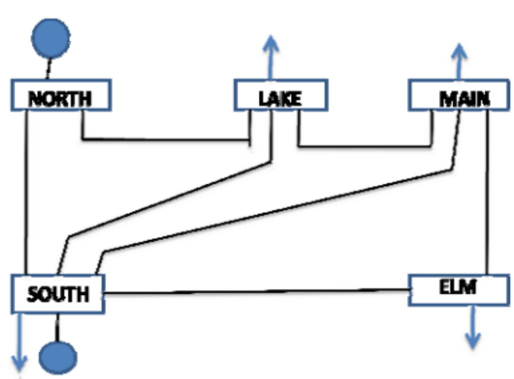

Fig 3: IEEE 5 – Bus test system

IV. Conclusion

The research shows the integration of Thyristor Controlled Series Compensator (TCSC) and Static VAR compensator (SVC) in enhancing power system voltage profiles when operating under normal conditions as well as under transient conditions. The operating range of bus voltage at connection can be controlled by SVC and TCSC whenever required. The L index method provides the required positioning criterion. The fast-decoupling method enables analysis of transient stability effects on real power changes.

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